

Advanced Materials and Cell Chemistries for HEV Application

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Introduction

The U.S. Department of Energy sponsors the Advanced Technology Development (ATD) Program to assist industrial developers of high-power lithium-ion batteries to overcome the barriers of cost, calendar life, and abuse tolerance so that this technology may be rendered practical for use in hybrid electric vehicles (HEVs) and fuel cell electric vehicles (FCEVs) under the FreedomCAR Partnership. All three of these barriers can be addressed by the choice of materials used in the cell chemistry. Our approach is to obtain the most advanced low-cost materials from international industrial material suppliers and evaluate them for use in high-power HEV and FCEV applications. We develop, refine, and employ standard screening test protocols for the various types of cell materials and components. The results of these screening tests are shared with the suppliers, along with recommendations for making their materials and components more optimal for high-power applications. In many cases, we have helped the suppliers refine their materials for use in HEV and FCEV batteries.

In prior years, we developed two high-power cell chemistries, referred to as our Gen 1 and Gen 2 baseline cell chemistries. The Gen 2 cell chemistry offers improvements in cost reduction and longer calendar life relative to the Gen 1 cell chemistry.

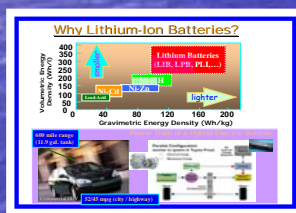
We work with each component of Li-ion batteries including cathodes, anodes, electrolytes and additives. Additional performance improvements and cost savings should be achievable by changing to different electrolyte salts. We are currently developing a new solvent system for use with lithium bis(oxalate)borate, a low-cost non-fluorine-containing salt, which is more compatible with the LiMn_2O_4 spinel cathode than LiPF_6 salt. This new salt, denoted LiBOB, does not react with trace amounts of water or alcohol to form HF, thereby stabilizing the LiMn_2O_4 spinel cathode against attack by HF. Use of this new low-cost salt could render the LiMn_2O_4 cathode ideal for HEV and FCEV battery applications. Additionally, the LiMn_2O_4 spinel cathode is much more thermally and chemically stable than the $\text{LiNi}_{0.8}\text{Co}_{0.15}\text{Al}_{0.05}\text{O}_2$ -type cathodes and this should enhance the inherent safety and extend the calendar life (if it can be stabilized against dissolution via HF attack).

ATD Program Goal and Challenges

Li-ion batteries have several advantages over other battery systems with high energy density and high-power density. In this way the HEV has a lighter weight, lower emissions, and higher fuel efficiency than the conventional vehicle. But challenges still exist for Li-ion battery in HEV high power application.

High-Power Li-Batteries for HEVs (DOE's ATD Program)

- Barriers:
 - 15-year calendar life
 - \$20/kWh cost
 - Operation between -30 & 52°C
 - Adequate safety for passenger vehicles
- Major DOE-funded R&D program to:
 - Understand factors that control life, inherent safety, & low-temperature performance
 - Develop low-cost cell materials that are more stable structurally, chemically, electrochemically, & thermally
 - Develop low-cost flexible cell packaging

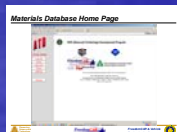


Information is Shared Freely

We make our results freely available through publications and an on-line database:

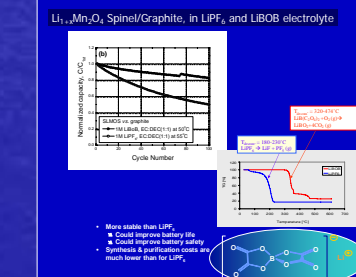
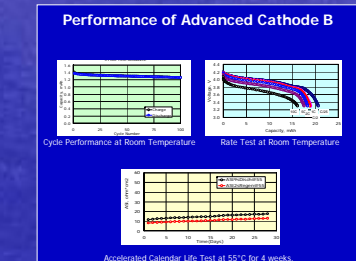
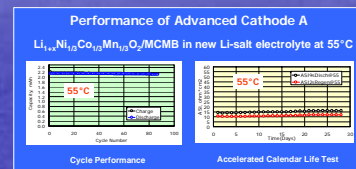
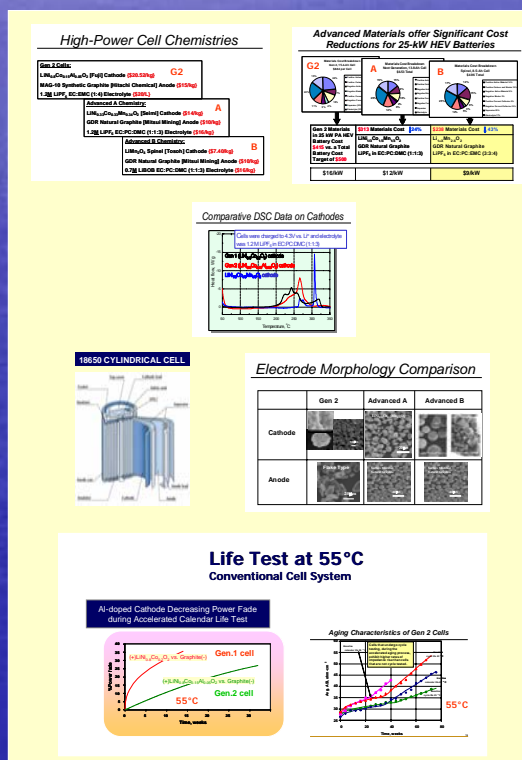
http://www.cmt.anl.gov/eatl/data/atd/atd_materials

Note: Database is username/password protected. Please contact Dr. Ira Bloom for further information (630-252-4516, bloom@cmt.anl.gov).



Argonne's Approach and Progress: Advanced Lithium-Ion Cell Chemistries

Rapid screening techniques were developed to select advanced materials, based on commercial availability, to improve the safety, calendar life and cell cost of high-power Li-ion batteries. Currently, we are working on two advanced cell chemistries: "A" employs a layered cathode active material that employs Mn as a major component and is easily synthesized using low-cost processing, and "B" is based on the LiMn_2O_4 spinel cathode material (which will provide the lowest cell/battery cost).



Summary

Argonne is evaluating and developing advanced materials and cell chemistries for use in high-power Li-ion batteries for HEV applications. The criteria under which they are being evaluated include cost, performance (power), and stability (life and abuse tolerance). Argonne's efforts have focused on two main systems: One based on the use of a $\text{Li}_{1-x}\text{Ni}_{0.5}\text{Co}_{0.15}\text{Mn}_{0.15}\text{O}_2$ layered cathode material and the other based on a partially stabilized $\text{Li}_{1-x}\text{Mn}_2\text{O}_4$ spinel cathode material. The spinel-based system is the most attractive in terms of cost and inherent abuse tolerance, but it suffers from limited calendar life under operation at elevated temperatures. We have established the mechanism that determines life at elevated temperature and made significant progress toward overcoming this limitation. The system based on a $\text{Li}_{1-x}\text{Ni}_{0.5}\text{Co}_{0.15}\text{Mn}_{0.15}\text{O}_2$ layered cathode seems to be the best near-term system, in that it offers some cost and abuse tolerance advantages over the state-of-the-art system, which is based on a $\text{LiNi}_{0.8}\text{Co}_{0.15}\text{Al}_{0.05}\text{O}_2$ cathode.